**TESTIMONY OF DR. JOHN C. WAGNER**

**LABORATORY DIRECTOR**

**IDAHO NATIONAL LABORATORY**

**BEFORE THE UNITED STATES SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES**

**"Full Committee Hearing to Examine the Nuclear Fuel Cycle"**

**March 9, 2023**

Chairman Manchin, Ranking Member Barrasso, and members of the committee, it is an honor and privilege to be here today. My name is John Wagner, and I am the director of Idaho National Laboratory (INL), the nation's nuclear energy research and development center. In this role, I lead a United States (U.S.) Department of Energy (DOE) national laboratory with more than 5,700 scientists, engineers and support staff, multiple nuclear and nonnuclear experimental facilities, and an annual budget of more than $1.6 billion with a mission focused on nuclear energy, national and homeland security, and energy and environmental science and technology.

I hold a Bachelor of Science degree in Nuclear Engineering from the Missouri University of Science and Technology and Master of Science and Doctorate degree in Nuclear Engineering from Penn State. Throughout my career, I have been intimately involved in technical issues related to the nuclear fuel cycle. My first position following graduate school was with a private company designing and licensing spent nuclear fuel storage and transportation systems. Later, during my employment at Oak Ridge National Laboratory (ORNL), I supported the U.S. Department of Energy (DOE) and the Nuclear Regulatory Commission (NRC) on a variety of technical issues related to long-term storage, transportation, and disposal of spent nuclear fuel, including serving as the national technical director of the DOE's Nuclear Fuels Storage and Transportation Planning Project – a project established to implement the recommended near-term actions in the Blue Ribbon Commission on America's Nuclear Future (BRC) report, and to lay the groundwork for implementing interim storage, including associated transportation. While at ORNL, I held various positions of increasing responsibility, ultimately the Director of the Reactor and Nuclear Systems Division. In February 2016, I joined INL as the Chief Scientist for the Materials and Fuels Complex, before becoming the Associated Laboratory Director for the Nuclear Science and Technology Directorate (NSTD). I am the author and co-author of more than 170 refereed journal and conference articles, technical reports, and conference summaries, some of which have more than one hundred citations. I am a Fellow of the American Nuclear Society and the American Association for the Advancement of Science.

Thank you for this opportunity to discuss an issue of great importance to our nation: the nuclear fuel cycle and its role in ensuring our future energy security.

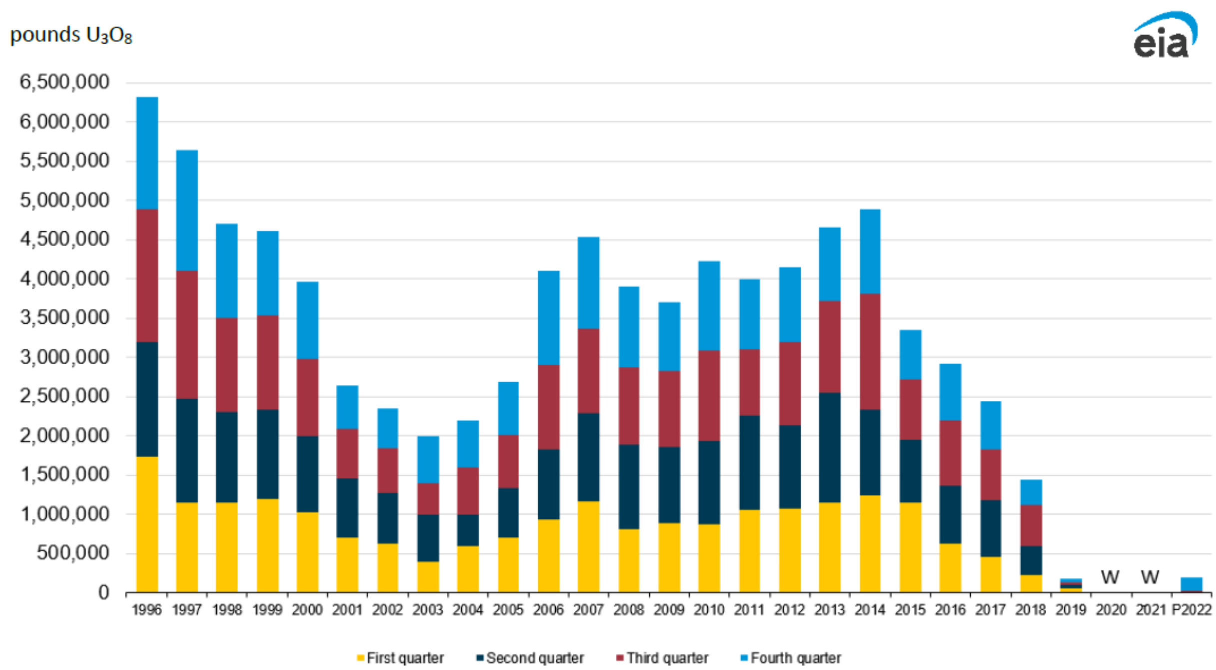
I want to thank members of this committee, including our own Sen. Risch of Idaho, for their longstanding and unwavering support for the U.S. commercial nuclear industry and for maintaining and expanding our global leadership in nuclear technology.

**Background**

I would like to begin today by addressing how we arrived at this point, where the vast majority of the uranium and processes involved with nuclear fuel production are not available domestically, making the United States dependent on international sources of nuclear fuel, including nations that do not have our best interests at heart.

As members of this committee well understand, the United States once built and deployed nuclear reactors regularly. And we maintained a robust domestic fuel cycle capability, from mining to conversion, to enrichment, to fuel fabrication.

That is no longer the case (Figure 1). In the United States, uranium mining has decreased 92% since 1980. For example, in 2021, the United States domestically produced only 5% of the uranium purchased, according to the U.S. government's Energy Information Administration (EIA).




P = Preliminary data

Source: U.S. Energy Information Administration, Form EIA-851A, *Domestic Uranium Production Report (Annual),* and Form EIA-851Q, *Domestic Uranium Production Report (Quarterly)*

*Figure 1. Uranium concentrate production in the United States, 1996 to fourth-quarter 2022.*

The only U.S. conversion facility was idled in 2017. Only one enrichment facility currently operates domestically, with the capacity to support about one third of the current reactor fleet, according to information compiled by the Urenco Group, which supplies nuclear power stations in 15 countries, including the United States.

The bipartisan passage of key nuclear energy-related legislation in recent years demonstrates that there is a broad understanding and consensus on nuclear energy's importance to our nation's economy, environment, national security, and power grid stability, security, and resiliency.

But our lack of domestic fuel cycle capabilities is already negatively impacting efforts to deploy the next generation of technologies needed to expand the ability of our commercial fleet to produce 24/7, carbon free power more than 92% of the time – more reliably than any other source of generation.[1] TerraPower recently extended the timetable on its Wyoming-based natrium reactor because of concerns about fuel availability.[2]

As we look to the future of nuclear energy in the United States, I would encourage members of this committee to consider the following questions related to the fuel cycle needs for the sustainment of the current nuclear reactor fleet and the expanded deployment of advanced reactor technologies, and waste storage and disposition.

1. How do we leverage our existing nuclear industry to ensure our domestic energy security?

Today's nuclear reactors, the 92 that make up the high-performing U.S. fleet, run on low enriched uranium (LEU), uranium fuel that is enriched up to 5% with uranium-235. Today, the United States imports over 90% of the uranium needed for our reactor fleet, which provides nearly 20% of the electricity produced for our power grid and more than half of our carbon-free electricity. That's more than solar, wind, hydro, and geothermal combined.

According to the EIA, owner and operators of U.S. nuclear power reactors purchased the equivalent of roughly 47 million pounds of uranium in 2021. Of that, 35% came from Kazakhstan, 15% from Canada, and 14% from both Australia and Russia.

Essentially, we no longer have sufficient capabilities to produce LEU in our nation, and our nuclear energy industry has become dependent upon foreign nations.

The Russian invasion of Ukraine puts the United States, and many other nations, in a precarious situation. The deteriorating relationship between our nations has resulted in increasing pressure, including from members of Congress, to call for an end to uranium imports from Russia. This step would require us to identify a path to operate our existing and future reactors without Russian imported uranium and supporting enrichment services.

In the short term, a reduction in supply, naturally, drives up costs. Given the already tenuous financial status of many U.S. nuclear power plants, this could result in even more premature

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[1] *What is Generation Capacity?* Office of Nuclear Energy, U.S. Department of Energy. https://www.energy.gov/ne/articles/what-generation-capacity#:~:text=The%20Capacity%20Factor&text=It%20basically%20measures%20how%20often,of%20the%20time%20in%202021.

[2] *Wyoming Nuclear Plant* Delayed. Nicole Pollack. December 25, 2022. Wyoming Business Report. https://www.wyomingnews.com/wyomingbusinessreport/current_edition/wyoming-nuclear-plant-delayed/article_3e898b50-7c37-11ed-8a07-fb56a5bad803.html.

closures, resulting in more carbon emissions from other generation sources and a less reliable and resilient power grid.

Developing new domestic mining, conversion, and enrichment capabilities, with urgency, will ensure the availability of a domestic supply of fuel, provide certainty to our existing fleet of nuclear power plants, and help ensure our domestic energy security.

2. How do we ensure successful deployment of new nuclear energy that is critical to our energy security, global leadership, and climate objectives?

While we must secure the sustained operations of our existing commercial reactors, at the same time we need to look to the future and support the advanced technologies that will help power American prosperity for decades to come.

Advanced nuclear technologies will run on high assay low enriched uranium (HALEU), uranium fuel that is enriched up to 20% with uranium-235. HALEU enables reactor developers to achieve smaller designs with more power per unit of volume, and to optimize their systems for increased efficiencies and better fuel utilization. DOE projects that deploying a new fleet of advanced reactors will require more than 40 metric tons of HALEU before the end of this decade.

This presents both a challenge and an opportunity.

Ideally, we would expand from a LEU fuel cycle to a HALEU fuel cycle. But current conditions are far from ideal because of the crippled state of our domestic LEU production capabilities.

The HALEU fuel needed to run advanced nuclear technologies, including microreactors and small modular reactors, offers our nation a real opportunity to reinvigorate our LEU fuel cycle. We can start by developing a 100% domestic HALEU fuel cycle which will add needed domestic mining, conversion, enrichment, and deconversion capabilities. According to a joint INL, Pacific Northwest National Laboratory, Argonne National Laboratory, and ORNL analysis, the HALEU fuel market is projected to be about 10% of the current LEU market by 2050.[3]

We also need to support the current needs of advanced reactor developers while new capabilities are deployed. At INL, we are actively working to supply HALEU from Experimental Breeder Reactor II origin and are making it available to companies such as Oklo for their microreactor demonstration. We are doing this by processing the high-enriched uranium (HEU) spent fuel to recover the uranium and down-blend it to HALEU. This material is not the only existing spent fuel in the DOE system that could be applied to beneficial use for HALEU production.

We are seeing real progress in our HALEU fuel cycle. In recent years, we have improved our understanding of the market and identified the demand, which is driven by government and private sector needs such as demonstration reactors, medical isotopes production, reactor

[3] Dixon, Brent; Kim, Son H.; Feng, Bo; Kim, Taek; Richards, Scott; and Bae, Jin Whan. (Dec. 2021). *Estimated HALEU Requirements for Advanced Reactors to Support a Net-Zero Emissions Economy by 2050*. Prepared for the U.S. Department of Energy, Office of Nuclear Energy. https://inldigitallibrary.inl.gov/sites/sti/sti/Sort_53484.pdf.

conversions, and space applications. With new private and government investments supporting the deployment of advanced reactors, the HALEU market is projected to significantly expand. INL is supplying small quantities of HALEU to industry to support fuel qualification and testing, and the Centrus enrichment demonstration is ongoing.

But much more remains to be done. As we move toward deployment of advanced reactors, to power our economy, combat climate change, and bolster national security, we need to accelerate the deployment of a self-sufficient, domestic HALEU fuel cycle.

3. How do we address the back end of the fuel cycle?

I began my remarks by talking about how decisions made decades ago, under far different conditions and circumstances, are impacting the fuel cycle today as we operate our nuclear reactor fleet and work to develop and deploy advanced technologies. The same can be said for spent fuel management and disposition.

The need to address our near- and long-term spent fuel management responsibilities remain. This is true for the existing and future DOE-managed and commercial inventory, and for the inventory arising from the anticipated deployment of advanced reactors. We have the technical capacity and knowledge to responsibly and safely manage spent nuclear fuel, but we need the support of an appropriate policy solution.

The Nuclear Waste Policy Act (NWPA of 1982), and as amended in 1987, understandably reflects the national priorities and concerns of the time. Various attempts have been made to further amend the NWPA to better reflect the nuclear waste management realities, policies, and needs of today, but none have yet succeeded. Simply put, the present framework for interim storage and disposal of the U.S. spent fuel inventory, as set forth in the NWPA, is inadequate to meet the challenges of today or tomorrow and a new policy framework is needed.

The near-term deployment of consolidated interim storage would be a useful component of an integrated waste management system, but the need for deep geologic disposal capacity remains. Congress has directed DOE to use a consent-based siting approach in the pursuit of federal consolidated interim storage for the nations spent nuclear fuel inventory. However, federal interim storage facilities of sufficient capacity cannot be constructed without first revising the NWPA, to remove the prerequisite for repository construction authorization and inadequate capacity limits.

While recycling of advanced reactor spent fuels is certainly possible, and even anticipated for some designs, the fact remains that there will always be a need for deep geologic disposal capacity. In the United States, as in the rest of the world, deep geologic disposal of spent nuclear fuel and/or high-level waste is the long-term endpoint, and the time has come to revisit our approach.

To provide for the fulfillment of our legacy spent fuel management responsibilities, and to fully realize the potential of our existing and future nuclear energy systems we must have a nuclear waste management policy framework that addresses the issues of today.

As a national laboratory, we are enabled to contribute to the ***technology*** for interim storage, recycling, and geologic disposal, and to ***inform*** the policy debates thereof. But the eventual resolution of those long-standing debates will require a new nuclear waste management framework, a framework that only Congress can provide.

I will conclude with this:

Private-sector companies contemplating investments in nuclear energy find themselves in a difficult situation. A fuel supply dependent upon imports, and now in doubt considering the Russian-Ukraine conflict, breeds uncertainty and stifles investments in the advanced technologies our nation needs.

More certainty in the fuel cycle, by developing a 100% domestic HALEU supply, would help alleviate uncertainty and inspire investments in microreactor technologies, small modular reactors, and other advanced nuclear technologies now in development.

I appreciate the opportunity to testify, and I want to thank the committee again for its attention to this important issue for our nation. I look forward to your questions.